Canada
Department of Mines
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Geological Survey

Museum Bulletin No. 23

GEOLOGICAL SERIES, No. 32 AUGUST, 1916

THE TRENT VALLEY OUTLET OF LAKE ALGONQUIN AND THE DEFORMATION OF THE ALGONQUIN WATER-PLANE IN LAKE SIMCOE DISTRICT, ONTARIO.

by

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OTTAWA
Government Printing Bureau
1916

No. 1639

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ILLUSTRATIONS.

August 21, 1916.

Canada
Geological Survey
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The Trent Valley Outlet of Lake Algonquin and the Deformation of the Algonquin Water-plane in Lake Simcoe District, Ontario.

By W. A. Johnston.

INTRODUCTION.

Lake Algonquin has long been known to have been the largest of the glacial, ice-dammed lakes which existed in the Great Lake region of North America at the close of the ice age. This lake overspread the basins of Lakes Superior, Michigan, and Huron and a portion of the adjacent regions. In Lake Ontario basin another ice-dammed lake, known as Lake Iroquois, existed. It has been generally inferred that Lake Iroquois for at least a part of its existence was contemporaneous with Lake Algonquin. The probability of an outlet of Lake Algonquin near Kirkfield, Ontario, and the occurrence of an abandoned river channel, apparently connecting the two lakes, along the line of the Trent Valley chain of lakes and rivers, was first recognized by J. W. Spencer. In 1888, Spencer[1] proposed the name "Algonquin River" for this ancient river. Two years later he stated, however, that he had overestimated the importance of this outlet and considered that the outlet was in existence only at the highest level of Lake Algonquin.[2] In

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[1] Spencer, J. W., "Notes on the origin and history of the Great Lakes of North America" (Abstract); Proc. Am. Assoc. for the Ad. of Sc., vol. 37, 1888, pp. 198–199.

[2] *Idem.*

1895, attention was again directed by Gilbert[1] to the Trent Valley outlet channel. Gilbert found evidence of powerful stream action at various places along the Trent valley. He noted that, between Stony lake and Rice lake the outflow was divided between the Indian River and Otonabee River valleys and that a delta, apparently formed by the Algonquin river, was deposited in Rice Lake basin at a height corresponding to the calculated position of the Iroquois water-plane, but also corresponding to the plane of Rice lake. He found also that the outlet channel does not stop at Rice lake but "continues with undiminished strength" down Trent River valley to the present level of Lake Ontario at Trenton. Gilbert pointed out that this indicated that the Algonquin river continued to flow long after the disappearance of Lake Iroquois. In 1893 Taylor had also examined the Trent Valley outlet channel and made the same observations that Gilbert did "except that the channel near Trenton seemed to him somewhat smaller and less capacious than that at Fenelon Falls and less thoroughly scoured; this, however, may be an error."[2] In 1903, Coleman[3] examined and mapped the Iroquois beach in Ontario. He showed that a delta apparently formed by the Algonquin river at Peterborough was deposited in a small lake, which he named Lake Peterborough. He considered that this lake was formed in a restricted valley tributary to Lake Iroquois. He found that the altitude of Lake Peterborough was somewhat higher than that of Lake Iroquois but no serious doubt was cast upon the correlative relation of the two lakes. More recently Goldthwait[4] has inferred from a comparison of the amount of uplift as shown by the warped water-planes of Lake Algonquin and Lake Iroquois that the two lakes must have been nearly contemporaneous, for both water-planes have apparently been upwarped by the same set of epeirogenic movements and the water-plane of Lake Iroquois shows very little greater deformation than that of Lake Algonquin.

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[1] Gilbert, G. K., "The Algonquin river" (Abstract). Am. Geol., vol. 18, 1896, p. 231.

[2] U. S. Geol. Surv., Mono. LIII, p. 444.

[3] Coleman, A. P., "The Iroquois beach in Ontario", Bull. Geol. Soc. Am., vol. 15, 1903, pp. 357–358.

[4] Goldthwait, J. W., "Isobases of the Algonquin and Iroquois beaches, and their significance", Bull. Geol. Soc. Am., vol. 22, 1910, pp. 227–248.

In 1908, an instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in southwestern Ontario was undertaken by Mr. J. W. Goldthwait under the direction of Mr. F. B. Taylor, the results of which were published as Memoir No. 10 of the Geological Survey, Canada. The Lake Simcoe district, Ontario, was included in the area examined by Taylor and Goldthwait and altitudes of the Algonquin shore-line were determined at a number of localities in the district. An isobasic map of the Algonquin beach and a profile of the warped Algonquin water-plane accompany the report. The map and profile show the direction and rate of tilt of the beach and the rapid steepening of tilt in the northern portion of the Lake Simcoe district. Goldthwait showed "that the strong Algonquin beach was formed during the activity of the Algonquin river as an outlet." His observations around Balsam and Cameron lakes also showed "that even in these small basins there is a distinct shore line which is either the extension of the Algonquin beach itself, or its contemporary in a chain of pools along the Algonquin river. A comparison of the five or six measurements in this district shows that if this shore line is the Algonquin it has suffered local warping of an unusual sort. Nowhere else in the Great Lake region where detailed work has been done, has a clear case of local warping of the Algonquin beach been discovered. The alternative is that this shore line on Balsam and Cameron lakes marks the outline of a chain of lakes between rapids on the ancient outlet; that in Balsam lake the water plane was originally lower than in Lake Algonquin, and in Cameron lake it was still lower."[1]

Lake Simcoe district, Ontario, is one of the most favourable localities in the Great Lakes region for a study of the character of the differential uplifts which are known to have taken place by the deformation of the Algonquin beach; for this beach is well developed in the district and can be followed continuously for long distances. It occurs on both sides of Lake Simcoe and its general trend on both sides is approximately in the direction of maximum uplift so that isobases or lines of equal deformation can readily be drawn and a profile constructed showing the

[1] Goldthwait, J. W., Geol. Surv., Can., Mem. 10, 1910, pp. 46–47.

present altitude of the ancient water-plane. Hence a detailed study of the raised beaches in this district affords data which are of value in determining the character and amount of the differential uplift which deformed the beaches.

The relation in time of Lake Algonquin and Lake Iroquois is of considerable importance in connexion with a study of the differential uplifts. In order to determine this relation, measurements of the altitudes of the raised beaches along the Trent valley and an examination of the outlet channel as a whole, for which no satisfactory interpretation has been given, were necessary.

The object of the present paper is to present the results of a detailed survey of the Algonquin beach in Lake Simcoe district, Ontario, and of its correlatives along the line of the Trent Valley chain of lakes and rivers, and hence to attempt to show the relation of Lake Iroquois to Lake Algonquin. In Lake Simcoe district the altitude of the Algonquin beach has been accurately determined at close intervals. By means of these altitudes a map showing isobases or lines of equal deformation of the Algonquin beach and a profile of the warped Algonquin water-plane, along the line of maximum uplift, have been constructed, by which an attempt is made to show the approximate character of the differential uplift which has affected the region during and since the existence of Lake Algonquin and its correlatives.

SHORE-LINES OF LAKE ALGONQUIN AND ITS CORRELATIVES, AND ALGONQUIN RIVER.

Lake Simcoe and Balsam Lake Districts.

In Lake Simcoe and Balsam Lake districts, Ontario, the following instrumental measurements of the highest Algonquin beach were made in 1908 by Goldthwait, Taylor, and the writer:[1]

[1] Goldthwait, J. W., Geol. Surv., Can., Mem. 10.

Locality	Altitude above sea-level, feet	Authority
Lefroy	775	Taylor and Johnston.
Big Bay point, 2 miles west	795	Taylor and Johnston.
Allandale	782	Goldthwait.
Barrie	785	"
Colwell	774	"
Gowan	795	"
Gowan, 1½ miles east	800	"
Oro	811	"
Hawkestone	821	"
Orillia	847	"
Silver creek	869	Taylor and Johnston.
Ardtrea	883	Taylor and Johnston.
Beaverton	822	Goldthwait.
Lorneville Junction	838 ?	"
Bolsover	857	"
Bolsover, ½ mile north	861	"
Bolsover, 1¼ miles north	865	"
Kirkfield, 1 mile north of station	883	"
Kirkfield, 1½ miles north of lift-lock	883	"
Kirkfield, 2 miles north of lift-lock	888	"
Victoria Road, 1 mile south	878	"
Victoria Road, 1¾ miles south	868	"
Victoria Road, hill east of high bridge	875	"
Balsam lake, west side near canal	867	"
Balsam lake, east side	895	"
Rosedale, ½ mile south	884	"
Balsam lake, south end	868	"

Instrumental measurements of the highest Algonquin beach in the district, determined by the writer, are as follows:

Locality	Altitude above sea-level, feet
Barrie, 3 miles west of town, strong gravel spit	779
Carthew, ½ mile southwest of Carthew, base of cut bluff	825
Orillia, 2½ miles southwest of Orillia, strong sand and gravel bar	843
1½ miles south of last, strong sand and gravel bar	842
1 mile southeast of last, strong gravel spit	839
Keswick, 1 mile north of Keswick, gravel beach ridge	776
Sutton, 1½ miles southwest of Sutton, strong gravel spit	787
3½ miles southwest of Sutton, strong gravel spit	781
2 miles south of Sutton, strong gravel barrier	787
2½ miles east of Sutton, strong gravel spit	793
Wilfrid, 2½ miles south of Wilfrid, on town-line, strong gravel bar	799
1½ miles north of Wilfrid, on town-line, gravel spit	805
1 mile northeast of last, strong gravel beach ridge	809
1½ miles northeast of last, strong gravel bar	816
Beaverton, 5 miles southeast of Beaverton, gravel bar	820
1½ miles northeast of last, gravel bar	822
1 mile northwest of last, gravel bar	824
1½ miles north of last, gravel bar	837
Argyle, 1 mile west of Argyle, gravel spit	841
1½ miles northwest of last, gravel spit	844
Kirkfield, 1 mile west of station, gravel beach ridge	876
2 miles southeast of village, gravel beach ridge	871
Horncastle, 1 mile southwest of Horncastle P.O., gravel beach ridge	901
2 miles northwest of last, gravel beach ridge	903
Carden, 1½ miles northeast of Carden post-office, gravel beach ridge	907
Uphill, ½ mile north of Uphill post-office, gravel beach ridge	925
Bexley, 1 mile east of Bexley post-office, gravel spit	900
1½ miles southeast of last, gravel beach ridge	901
Balsam lake, near west side of lake, 2 miles southeast of Corson, gravel spit	892
Near west side of lake, 2½ miles east of Victoria Road, gravel bar	879
Southwest side of Balsam lake, on long point, gravel beach ridge	874

Locality	Altitude above sea-level, feet
Near south end of point at north side of Balsam lake, gravel bar	898
Near north end of large island in lake, gravel beach ridge	889
Near south side of island, gravel spit	882
Southeast side of lake, 2 miles southwest of Rosedale, gravel beach ridge	880
Baddow, 1½ miles north of Baddow post-office, gravel beach ridge	904
Rosedale, 1 mile southeast of lock, gravel beach ridge	881
Cameron lake, west side of lake, near school, gravel beach ridge	875
Southwest side of lake, gravel beach ridge	866
South side of lake, 1 mile west of Fenelon Falls, gravel beach ridge	869
East side of lake, 1½ miles north of Fenelon Falls, gravel beach ridge	878

The preceding altitudes have been used in the construction of the isobasic map accompanying this report.

There can be little doubt that the beach which extends eastward from Kirkfield to Fenelon Falls and surrounds Balsam and Cameron lakes is the highest Algonquin beach. A narrow passage 1½ miles east of Kirkfield connected the Balsam Lake embayment with the main body of the lake, but there is no good evidence that there was any fall at this point. The passage was divided into two portions by an island composed of drift. On the west side of the island the passage was one-half mile wide with a maximum depth of 40 feet. On the east side of the island the passage was slightly over one-half mile wide with nearly the same maximum depth as on the west side. At the east end of the island a strong gravel spit occurs which was evidently built directly out into the passage. The passage is very short and broadens almost immediately on either side so that it does not seem possible that a fall took place at this point during the highest stage of Lake Algonquin. It is, therefore, held that the

Algonquin beach extends eastward past Kirkfield and formed an embayment in the Balsam Lake and Cameron Lake basins. At Fenelon Falls, however, a fall occurred and this point marks the beginning of the Trent Valley outlet channel of Lake Algonquin.

It is known that the highest Algonquin beach south of the Trent Valley outlet isobase is a record of a "two outlet" stage of Lake Algonquin when the discharge was divided between the St. Clair outlet and the Trent Valley outlet.[1] It is probable, as Gilbert[2] and Taylor[3] concluded, that the highest Algonquin beach north of the Trent Valley outlet isobase is a record of an early stage of Lake Algonquin before "the outlet was diverted by terrestrial deformation" from the Trent valley to Port Huron, so that the continuation of this beach south of the Trent Valley outlet isobase would fall below the highest Algonquin beach in that region. In Lake Simcoe district, however, the highest beach appears to be equally well developed both north and south of the outlet isobase and the distance is so short that, probably, no serious error is involved in correlating the highest beach north of the outlet isobase with that south of it.

Sturgeon Lake Basin.

In Sturgeon Lake basin, which is connected with Balsam and Cameron Lake basins by a short stretch of river, a strong raised beach occurs. The beach is considered to be a correlative of the highest Algonquin beach because of the connecting channel at Fenelon Falls and because the beach is remarkably strong and is not horizontal but shows approximately the same amount of deformation that is shown by the Algonquin beach. Instrumental measurements of the altitude of this beach were secured at a number of localities as follows:

[1] Goldthwait, J. W., Geol. Surv., Can., Mem. 10, 1910, p. 15.
[2] Gilbert, G. K., "The Algonquin river" (Abstract), Am. Geol., vol. 18, p. 23.
[3] Taylor, F. B., U.S. Geol. Surv., Mon. LIII, 1915, pp. 412–413.

Locality	Altitude above sea-level, feet
Sturgeon lake: west side of Sturgeon lake, 1 mile south of Fenelon Falls, gravel beach ridge	832
¼ mile south of last, gravel beach ridge	831
1½ miles south of last, gravel bar	826
2½ miles south of last, gravel beach	820
East side of Sturgeon lake, 3½ miles south of Fenelon Falls, gravel beach ridge	824
North side of Sturgeon lake, ½ mile east of Sturgeon point, gravel beach ridge	824
2½ miles northeast of last, gravel spit	829
1 mile east of Red Rock post-office, gravel spit	833
1 mile west of Bobcaygeon, base of cut bluff	830
South side of Sturgeon lake, opposite Sturgeon point, gravel beach ridge	819
1 mile east of last, gravel beach ridge	819

Near the entrance to the bay in the southwestern part of the lake the ancient beach nearly coincides with the present beach and in the southern part of the bay the plane of the ancient water level apparently passes beneath the present water level. These altitudes show that the abandoned beach in Sturgeon Lake basin is on a distinctly lower plane than that of the highest Algonquin beach in the adjacent Cameron and Balsam Lake basins. The connecting outlet channel at Fenelon Falls is nearly a mile wide and is in large part rock floored. The bared rock floor and undercut banks on the valley sides show evidence of strong river action. The present river has a fall of 23 feet over a sill of Trenton limestone and it is evident that the ancient Algonquin river also had a considerable fall at this point. It is impossible to directly measure the height of the ancient fall but it can be arrived at approximately by taking the difference in altitude of the correlative beaches, at the nearest points above and below the fall, and subtracting the amount of uplift. This gives approximately 30 feet for the total fall in the ancient outlet channel at Fenelon Falls. The total fall was probably

partly taken up by rapids above the direct fall which was nearly three-quarters of a mile below the head of the outlet channel.

Pigeon-Buckhorn Lake Basins.

In Pigeon-Buckhorn Lake basins, a raised shore-line, which is probably a correlative of the highest Algonquin shore-line, also occurs. Instrumental measurements of the altitude of this beach were secured at five localities as follows:

Locality	Altitude above sea-level, feet
Pigeon lake: west side of Pigeon lake ½ mile north of mouth of Bobcaygeon river, base of cut bluff	829
¾ mile north of last, base of cut bluff..................	833
West side of Pigeon lake 1½ miles south of mouth of Bobcaygeon river, gravel beach ridge....	819
3 miles south of last, gravel spit......................	809
Little Mud lake: at the northeast end of Little Mud lake, faint shore cutting..................................	813

No evidence was found of the existence of a shore-line above the present shore-line around the southern part of Pigeon lake or on Chemong lake and it is probable that the plane of the ancient water level passes beneath the present water level in the southern part of these basins, as it does in the southwestern part of Sturgeon Lake basin. The northern shores of these lakes are generally rocky and likely to afford little evidence of wave action. They have not been carefully examined. The beach is remarkably well developed, however, north of Bobcaygeon and there can be little doubt that it extends around the northern portion of the Pigeon-Buckhorn Lake basin.

A strongly scoured, rock-floored channel at Bobcaygeon (Plate I) near the northeastern end of Sturgeon lake, affords evidence of powerful river action and marks the second fall in the ancient outlet channel. The present fall from Sturgeon to

Pigeon lake is 7 feet. The amount of descent in the ancient river, as determined from a comparison of the altitudes of the correlative beaches in the two basins, was about 6 feet.

Stony Lake-Rice Lake District.

From Buckhorn lake to Stony lake the present descent by a series of rapids and falls is 39 feet. It is not known what the descent in the ancient river was, but it was probably not as great as the present fall, for the ancient water-plane was higher than the present in these basins. This would have resulted in a drowning out of part of the rapids and falls.

On the south side of Stony lake near Indian River outlet, a strong gravel spit, apparently marking a correlative of the highest Algonquin beach, occurs at 796 feet. On the south side of Stony lake near the entrance to Clear lake a faint gravel beach ridge also occurs at 788 feet.

In Katchiwano Lake basin, southwest of Clear lake, a faint shore-line, which is apparently nearly horizontal, occurs at a height of 10 feet above the present lake-level. The altitude of the water-plane represented by this beach was determined by the rock sill at the outlet near Lakefield at a time previous to the lowering of the outlet by stream erosion. This beach is not, probably, a correlative of the raised beach in Stony Lake basin, for it is not similarly deformed. It is also evident that the tilt rate of the raised beach in Stony Lake basin is sufficient to carry the water-plane below the altitude of the controlling sill at the southwestern end of Lake Katchiwano. Hence there was no possibility of an outlet from Clear lake and Katchiwano lake by way of the Otonabee River valley past Peterborough, at least not until uplift had sufficiently progressed to cause an overflow by way of the Otonabee River valley.

Stony lake has at present two outlets, one by way of Indian river past Keene to Rice lake, and the other and much the larger by way of the Otonabee river through Peterborough to Rice lake. During the greater part of the existence of the Trent Valley outlet of Lake Algonquin the outlet river from Stony Lake basin was by way of the Indian River valley down to

Rice Lake basin. The present stream in the southern portion of this valley is only about 100 feet wide with a maximum depth of about 3 feet. The valley in which the stream flows is generally nearly a mile wide. It is in places rock-floored and strewn with boulders. The sides of the valley are frequently undercut and the valley as a whole shows marked evidences of powerful stream erosion (Plate II). Where Indian river enters Rice lake a large delta, which is only slightly submerged at the present level of Rice lake, fills the wide bell-shaped mouth of the river and extends for some distance out into the lake. This delta could not have been built by the present stream for the stream is too small and its valley was so thoroughly scoured by the ancient river that little sediment was available for transportation. It is, therefore, evident that this delta is to be correlated with the ancient Algonquin river.

Another large delta occurs, as noted by Coleman, along the Otonabee river at Peterborough. A lake, which Coleman named Lake Peterborough, was formed in the vicinity of Peterborough when the drainage was largely diverted from the Indian River valley to Otonabee valley by differential uplift. Between Peterborough and Rice lake, drift hills blocked the drainage and for a time held the lake up. Laminated clays were first deposited in the lake. These were followed by delta sands and gravels which are thicker and coarser in character in the northern portion of the basin than in the southern portion. The lake was drained by the cutting of a relatively narrow and deep valley through the range of drift hills and ridges which had blocked the drainage. It is probable that the Otonabee River valley carried part of the outflow of Lake Algonquin for a short time during the "two-outlet" stage of the lake before the discharge was entirely diverted from the Trent outlet by uplift. This seems to be borne out by the size of the outlet channel along the Otonabee River valley, for it is apparently somewhat larger than could be accounted for by the present drainage. The Indian River valley was, however, the main channel of outflow. Lake Peterborough and the Otonabee outlet channel are not shown on the accompanying map because their correlation with Lakes Algonquin and Iroquois appears doubtful.

RELATION OF LAKE ALGONQUIN TO LAKE IROQUOIS.

It is evident that the delta in Rice lake at the mouth of Indian River valley was not formed by the present stream but must have been formed by the Algonquin river. The question arises whether the water body in which it was deposited was Lake Iroquois or a lake which existed in Rice Lake basin after the disappearance of Lake Iroquois. This question can be answered by an examination of the altitudes of the Iroquois shore-line in Rice Lake and Campbellford districts.

The altitude of the highest Iroquois beach near Healey falls, 5 miles north of Campbellford, was determined by the writer, by levelling from a bench-mark established at Healey falls. The altitude of the highest strong gravel beach ridge was found to be 689 feet. A lower strong beach occurs at 679 feet. These altitudes confirm Coleman's determination of the altitudes of Iroquois beaches at this point.[1] On the north side of Rice lake, 3½ miles east of the mouth of Indian river, a well marked beach, which is probably the highest Iroquois beach, occurs at 621 feet. A strong shore cutting slightly above the present level of Rice lake also occurs near the mouth of Indian river. The trend of the isobases of Lake Iroquois, assuming for this district the direction of tilt north 20 degrees east as determined by Coleman,[2] also indicates that the Iroquois water-plane would coincide with the plane of Rice lake not far west of the mouth of Indian river. Rice lake owes its present existence to drowning of a large valley by uplift of the outlet. The lake could not have existed previous to the uplift which is shown to have taken place by the deformation of the Iroquois beach, unless the water body which occupied Rice Lake basin was an embayment of Lake Iroquois. The delta was formed before uplift took place. Hence it seems evident that the delta at the mouth of Indian river is to be correlated with Algonquin river and Lake Iroquois and it follows that Lake Iroquois was for a time at least, contemporaneous with an early stage of Lake Algonquin.

The continuance of a strongly marked outlet channel along Trent river below Rice lake and extending as far as Trenton on

[1] Coleman, A. P., "The Iroquois beach in Ontario," Bull. Geol. Soc. Am., vol. 15, 1903.
[2] *Loc. cit.*, pp. 359–363.

Lake Ontario presents a problem that is difficult of explanation. The uplift which deformed the Algonquin and Iroquois shore-lines began after the establishment of the Trent Valley outlet and was in part accomplished during the existence of the lakes, for the shore-lines diverge in altitude in the direction of maximum uplift. The Iroquois shore-lines, however, are not so numerous nor do they show so much divergence as those of Lake Algonquin. This seems to show that Lake Iroquois was largely drained while Lake Algonquin was still in existence. But it does not seem possible that the water in the Ontario basin could have fallen as low as the present level of Lake Ontario, while the Algonquin river was still flowing, for this was far below the level of marine submergence.[1]

The outlet channel along the Trent valley below Rice lake is well marked near Campbellford, where 20 feet of river gravels overlie laminated clays. South of Campbellford at the great bend of the Trent a large delta built in a body of standing water occurs. North of Frankfort, 10 miles above Trenton, the Trent river occupies a deep gorge which has been cut through the range of drift hills known as the Murray hills which trend in an east and west direction nearly parellel to Lake Ontario. The strong outlet channel along the Trent between Frankford and Trenton may be due to rapid down-cutting of this channel through the drift hills and the consequent releasing of the ponded waters, after the disappearance of Lake Iroquois, and may be post-Algonquin in age. The size of the outlet channel, however, makes this explanation seem doubtful.

It seems probable that the outlet channel below Rice lake is to be correlated with the Otonabee outlet channel. It was probably partly formed during the existence of the "two-outlet" stage of Lake Algonquin and may be in part post-Algonquin in age. Its exact relation to post-Iroquois water-bodies in the Ontario basin is not known.

It was not found possible with the data at present available to accurately determine the total fall from Lake Algonquin to Lake Iroquois. The fall at the outlet of Lake Algonquin at

[1] Coleman, A. P., "Marine and freshwater beaches of Ontario", Bull. Geol. Soc. Am., vol. 12, 1901.

Fenelon Falls was approximately 30 feet. At Bobcaygeon the fall was about 6 feet. Between this point and Stony lake the present fall is 39 feet. It is probable that the ancient fall was not as great, for the altitude of the ancient water-plane was higher than the present which would have resulted in a drowning out of part of the rapids and falls. From Stony Lake basin to Rice Lake basin the amount of fall in the ancient Algonquin river was equal to the difference in altitude of the correlative beaches in the two basins, approximately 175 feet, less the amount of uplift. The amount of uplift as determined from the rate of tilt of the Iroquois beach in the Rice Lake-Campbellford district and assuming the direction of tilt to be north 20 degrees east is approximately 100 feet. This gives 75 feet as the amount of fall in Algonquin river from Stony Lake basin to Rice Lake basin. So that it seems probable that the total amount of fall from Lake Algonquin to Lake Iroquois, granting that the delta at the mouth of Indian river was deposited in Lake Iroquois, did not exceed 150 feet. This amount of fall is about 100 feet less than the calculated difference in altitude along the same isobase, of the highest Algonquin beach in the southern part of the Huron basin and of the Iroquois beach in the southwestern portion of the Ontario basin. This seems to show that Lake Iroquois was contemporaneous with an early stage of Lake Algonquin which existed before uplift had raised the level of the water in the southern part of the Huron basin and transferred the outlet from Fenelon Falls to Port Huron. This confirms Gilbert and Taylor's conclusion that the original Algonquin beach is seen only in the region north of the Trent Valley outlet isobase and that south of this isobase the beach of this stage was considerably lower than the highest beach of the later "two-outlet" stage.

Evidence which further confirms this conclusion as to the rise of the Algonquin waters in the southern part of the basin was found, by the writer, in the southern portion of Lake Simcoe district. Sections exposed on the shore of Lake Simcoe, 2 miles east of Jackson point, show a distinct break in the lacustrine sands of Lake Algonquin. The sands in the upper portion of the section contain numerous fossil freshwater shells of several

species. They were determined by E. M. Kindle, of the Geological Survey, to be *Lymnia palustrius* Muller, *Lymnia decollata* Mighels? *Valvata tricarinata* Say, *Valvata sincera* Say, and *Sphaerium rhomboideum* Say. Mollusca of all these species have been found to be living in Georgian bay.[1] No fossil shells were found in the sands of the lower portion of the section. The shell-bearing sands occur at this locality at altitudes of 730 to 735 feet above sea-level. Fossil shells of similar species were also found in the deposits of the highest shore-line of Lake Algonquin near Roches Point and at Wilfrid at altitudes of 775 and 800 feet respectively. The distinct break in the lacustrine sediments shows that the water must have risen. The occurrence in the deposits of the highest shore-line of Lake Algonquin of fossil shells of mollusca similar to those living in Georgian bay, and the fact that the fossil shells are only slightly reduced in size show that temperature conditions of the water could not have been much more severe than at present. This is also borne out by the general absence of ice "ramparts" on the abandoned shores of Lake Algonquin and the rare occurrence of boulders in the lacustrine deposits of the lake. No fossil shells are known to occur in the older deposits of the early stage Lake Algonquin before it reached its maximum extent and ice-rafted boulders more commonly occur in these deposits, apparently showing a more frigid temperature of the water. The magnitude of the vertical interval through which the waters rose before reaching their maximum extent, as shown by the highest shore-line of Lake Algonquin, is not definitely known. In the southern portion of Lake Simcoe district it was apparently at least 50 feet, for the vertical interval between the base of the fossiliferous sands, which show an unconformable relation to the underlying deposits, and the crest of the highest Algonquin beach at the nearest locality which is on the same isobase is about 65 feet. The magnitude of this vertical interval in the southern portion of Lake Simcoe district suggests that the rise of the waters was not entirely due to uplift of the northern portion of the Algonquin basin and consequent drowning of the southern shores of the lake, but that a general rise of the lake level took place, due possibly to a

[1] Robertson, A. D., "The Mollusca of Georgian bay," Sessional Paper No. 39b, 1915.

readvance of the ice. The remarkable continuity and uniformity in strength of the highest Algonquin shore-line both north and south of the Trent Valley outlet isobase is also difficult of explanation unless it is all of the same age.

DESCRIPTION AND INTERPRETATION OF OUTLINE MAP AND PROFILE, SHOWING CHARACTER OF THE DIFFERENTIAL UPLIFT.

The accompanying map is an outline of the Lake Simcoe and Trent Valley region of southern Ontario. On this outline is shown the highest Algonquin shore-line in Lake Simcoe district and its correlatives along the line of the Trent Valley chain of lakes. The Algonquin river and the shore-line of Lake Iroquois are also shown. The Iroquois shore-line is probably not a correlative of the highest Algonquin shore-line, in the southern portion of Lake Simcoe district. Altitudes of the highest Algonquin shore-line and its correlatives are shown in feet above sea-level at localities where measurements have been made. The altitudes are all instrumental determinations. In most cases the lake levels were used as a datum plane, the altitudes of which were determined from bench-marks established by precise levelling by the Public Works Department of Canada. The shore-line of Lake Iroquois is taken from Coleman's map of Lake Iroquois accompanying the Bureau of Mines report for Ontario, 1904, with slight modifications in Rice Lake area. The altitudes of the Iroquois shore-line at Silver lake and near Trenton are also instrumental determinations by Coleman. Isobases, or lines of equal deformation, of the Algonquin beach and its correlatives and the direction of tilt or maximum uplift are also shown on the map, the isobase interval being 10 feet.

The fact that the isobases are closer together in the northern than in the southern portion of the district shows that the plane of the Algonquin shore-line is more steeply inclined in the former than in the latter. Near Beaverton in the central portion of the area there is an irregularity in the rate of uplift as shown by the closer spacing of the isobases. In the Kirkfield-Balsam Lake district there are remarkable irregularities in the trend of the isobases showing marked changes in the direction of tilt and in the character of the uplift.

The line AB drawn perpendicular to the isobases shows the direction of tilt or maximum uplift. In the southern part of the district the direction of tilt is about north 26 degrees east. Near Beaverton the direction changes to about north 22 degrees east. In the northern part, the direction is apparently irregular, but in general shows a marked change to a more northerly course. In the Balsam-Cameron Lake area, the direction is nearly due north.

A small fold and fault, the location of which is shown on the map, occurs and is seen in cross-section in a cutting in Trenton limestone along the Trent canal near Kirkfield (Plate III). The fault appears to be recent in age. It is reverse in character and is evidently due to a slight buckling or thrust. It was found by cleaning out the fault surface that the walls were slickensided in places in a nearly horizontal direction indicating a transverse movement. The fact that the fault occurs just where the marked change in the trend of the isobases occurs and the character of the fault suggests that there was a casual relation between the uplift which caused the irregular deformation of the Algonquin beach in this area and the development of the fault. The isobases are shown by broken lines in the Kirkfield-Balsam Lake area, for it is not known exactly how they should be drawn. It is possible that there are slight offsets in the isobases in the faulted area.

The marked change in the rate and direction of tilt or maximum uplift in the northern portion of the district seems to show that there is a sort of "hinge line" or zone here. The region north of this zone was affected by a set of movements which did not affect or only slightly affected the region south of this zone. The direction of maximum uplift which was the result of the later movements was more nearly north than that of the earlier movements.

The profile of the warped Algonquin water-plane along the line of tilt AB is intended to show approximately the character of the differential uplift which deformed the water-plane.

In the construction of this profile accurate topographical maps drawn on a field scale of 4,000 feet to the inch were used, from which the location of the different points at which the alti-

tude of the beach was determined and the distances between these points were secured. The altitudes are all instrumental determinations and so far as the actual levelling is concerned, they are believed to be correct within a possible error of one foot, except in the case of the three most northerly ones which, because of the distance over which the levels were carried, may not be so nearly correct.

It is not held that the profile shows the exact character of the warped water-plane, for it is recognized that the altitudes of the shore-line do not truly represent the altitudes of the water-plane. The altitudes are all, however, of wave-built features such as beach ridges, barrier beaches, etc., and the exposure to wave action was fairly uniform throughout the area, so that there is likely to be a fairly close agreement between the altitudes of the beaches and the altitudes of the water-plane. It is considered that the difference at any one locality due to the greater or less development of the shore features and errors in levelling would not exceed 5 feet.

The profile shows that there is at least one locality in the district where there is a marked irregularity in the rate of uplift. Between Beaverton and Lorneville the beach rises from 824 to 838 or 14 feet in a distance of $1\frac{3}{10}$ miles. If the altitude 838 of the beach is accepted, the beach rises 14 feet in less than one-half mile. The altitude of the beach as determined at this point may, however, be too high and it need not be taken into consideration. South of Beaverton the altitudes of the beach show a rise of only 8 feet in a little over 5 miles. North of Lorneville the beach rises 7 feet in $2\frac{1}{2}$ miles. The marked increase in the rate of rise of the beach between Beaverton and Lorneville is too great to be accounted for by greater development of the beach at one point than at another. The field evidence also shows that this is not the case. The sudden increase in the rate of tilt at this point is confirmed by the altitudes of the beach along the same isobases on the opposite side of Lake Simcoe, where the beach rises 14 feet in $1\frac{1}{4}$ miles. The beach can be traced continuously at these localities. No evidence of faulting was seen and the sudden increase in the rate of tilt is apparently due to local warping. The irregularity in the profile between Beaverton

and Lorneville and possibly at two other localities, viz., north of Wilfrid and north of Kirkfield, contrasts with the even character of the profile south of Wilfrid. At all three localities the over-steepened portions of the profile are preceded and followed by more nearly horizontal portions. The evidence suggests that the character of the deformation is that of differential warping. The rate of uplift increases towards the north but is interrupted by local irregularities. Because of errors involved, however, in assuming that the altitudes of the beaches truly represent the altitudes of the water-plane it does not seem possible to demonstrate what was the exact character of the epeirogenic movements which deformed the ancient water-plane.

The deformation of the highest Algonquin beach forms a record of the differential uplift which took place during the existence of the lake and after its disappearance. It is probable, as Taylor has pointed out, that uplift took place, also, previous to the inception of Lake Algonquin, so that the tilt rate as shown on the accompanying map and profile does not represent the total amount of uplift. It is probable, however, that the earlier uplifts affected more particularly the southern portion of the Great Lake region and that there was a "northward migration of the zone of deformation."[1] This is shown in Lake Simcoe district by the marked change in the direction of maximum uplift and by the rapid increase in rate. The northward migration of the zone of deformation or wave of uplift proceeding from south to north, taken in conjunction with the probability that the highest Algonquin beach in the southern portion of the Great Lake region is a transgressional beach, that is it represents a long still-stand of the waters following a rise due to uplift of the northern part of the basin, explains why the highest Algonquin beach is practically horizontal over a considerable part of the southern portion of the Great Lake region.

SUMMARY.

The ancient Algonquin river or outlet channel of Lake Algonquin, along the line of the Trent Valley chain of lakes and rivers, began at Fenelon Falls and not at Kirkfield as has

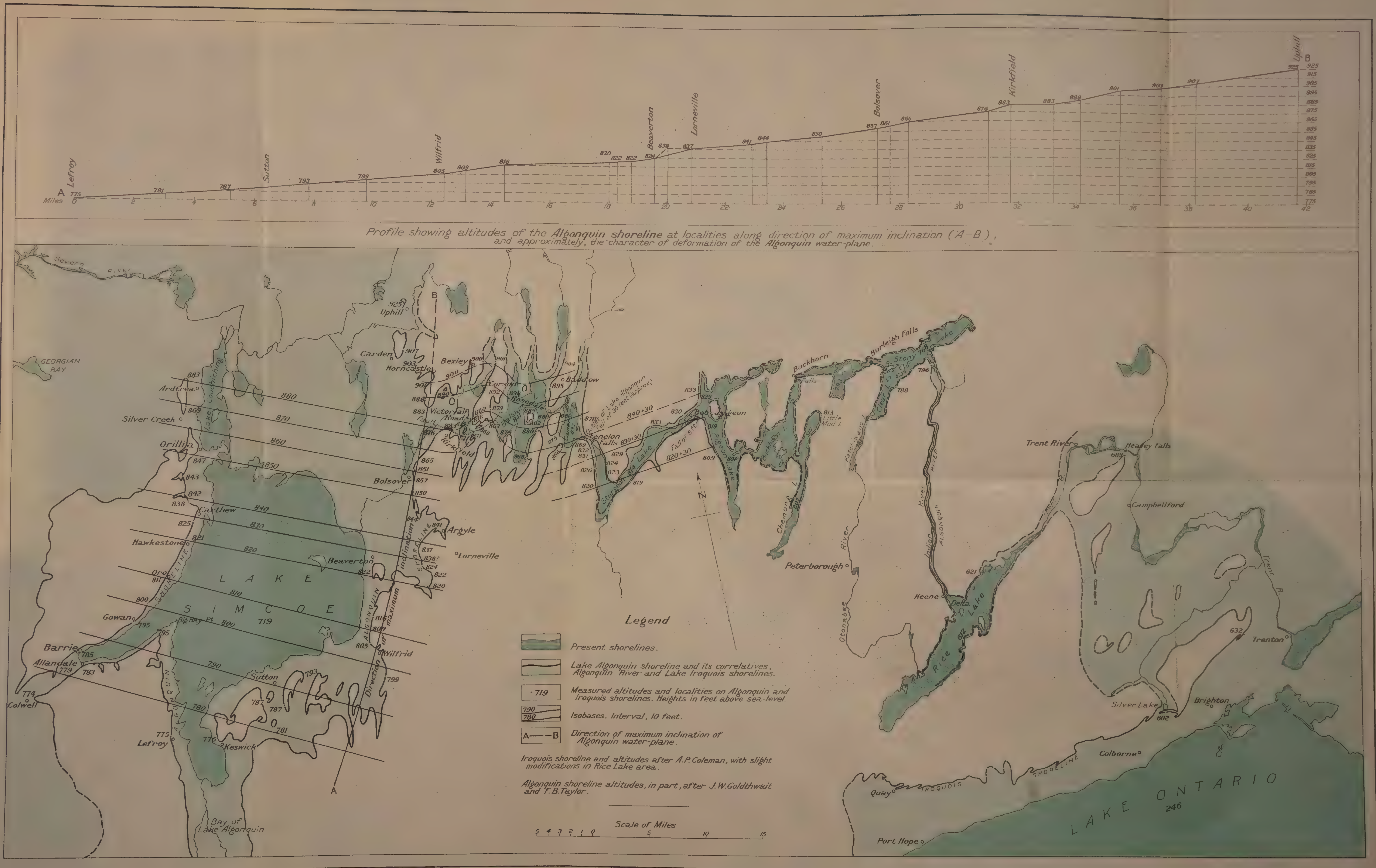
[1] Goldthwait, J. W., Wisconsin Survey Bulletin XVII, p. 115.

been generally supposed. Correlative shore-lines of the highest Algonquin shore-line occur in several basins along the Trent valley. Strongly marked outlet channels show that the ancient water bodies in these basins were connected with each other and with the Balsam Lake embayment of Lake Algonquin. The main channel of the ancient Algonquin river between Stony Lake and Rice Lake basins was by way of the Indian River valley. At the mouth of this valley in Rice Lake basin a large delta occurs. This delta was deposited in Lake Iroquois and was formed by the Algonquin river during an early stage of Lake Algonquin when the discharge was largely by way of the Trent valley. The Otonabee outlet channel and Peterborough delta are correlated with the "two outlet" stage of Lake Algonquin when the discharge was divided between the Trent valley and St. Clair outlet. They are probably post-Iroquois in age. The strong outlet channel along Trent valley below Rice lake is correlated with the Otonabee Valley channel. Its exact relation to the post-Iroquois water bodies in the Ontario basin is not known.

The total fall in the Algonquin river from Lake Algonquin to Lake Iroquois probably did not exceed 150 feet. This is about 100 feet less than the difference in altitude of the two lakes as determined from a comparison of the altitudes of the Algonquin and Iroquois beaches in the southern part of the Huron and southwestern part of the Ontario basins respectively. This seems to show as Gilbert and Taylor concluded that, previous to the Algonquin uplift, and during the early stage of Lake Algonquin, when the discharge was largely by way of the Trent valley, the plane of Lake Algonquin was much lower in the southern part of the Huron basin than it was at the later "two-outlet" stage of the lake when the discharge was divided between the Trent outlet and the St. Clair outlet.

An isobasic map of the Algonquin beach and a profile of the warped Algonquin water-plane in Lake Simcoe-Balsam Lake district show that there are remarkable changes and irregularities in the direction and rate of uplift. The profile of the warped Algonquin water-plane along the line of maximum uplift seems to show that the character of the deformation is

that of differential warping. The rate of warping increases towards the north but is interrupted by local irregularities. The marked change in the direction and rate of uplift in the northern part of the district seems to show that there is a sort of "hinge line" or zone here; the region north of this line or zone was affected by epeirogenic movements which did not affect or only slightly affected the region south of it. The direction of maximum uplift, which was the result of the later set of movements, was more nearly north than that of the earlier uplift.



Geological Survey, Canada.

Diagram showing shorelines of **Lake Algonquin** and **Lake Iroquois**

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To accompany Museum Bulletin by W.A. Johnston.

Scoured rock floor of ancient Algonquin River channel at Bobcaygeon, Ontario.

East limit of ancient Algonquin River channel near Keene, Ontario.

Small fold and fault in Trenton limestone, Trent canal, Kirkfield, Ontario; looking southeast along strike of fault.

LIST OF MUSEUM BULLETINS.

The Museum Bulletins, published by the Geological Survey, are numbered consecutively and are given a series number in addition, thus: Geological Series No. 1, 2, 3, etc.; Biological Series No. 1, 2, 3, etc.; Anthropological Series No. 1, 2, 3, etc.

In the case of Bulletins 1 and 2, which contain articles on various subjects, each article has been assigned a separate series number.

The first Bulletin was entitled *Victoria Memorial Museum Bulletin;* subsequent issues have been called *Museum Bulletins.*

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Geol. Ser. 2. Note on Merocrinus, Walcott—by F. A. Bather.

Geol. Ser. 3. The occurrence of Helodont teeth at Roche Miette and vicinity, Alberta—by L. M. Lambe.

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Geol. Ser. 9. A new Brachiopod from the base of the Utica—by A. E. Wilson.

Geol. Ser. 10. A new genus of dicotyledonous plant from the Tertiary of Kettle river, British Columbia—by W. J. Wilson.

Geol. Ser. 11. A new species of Lepidostrobus—by W. J. Wilson.

Geol. Ser. 12. Prehnite from Adams sound, Admiralty inlet, Baffin island, Franklin—by R. A. A. Johnston.

Biol. Ser. 1. The marine algæ of Vancouver island—by F. S. Collins.

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MUS. BULL. 2. *Geol. Ser. 13.* The origin of granite (micropegmatite) in the Purcell sills—by S. J. Schofield.

Geol. Ser. 14. Columnar structure in limestone—by E. M. Kindle.

Geol. Ser. 15. Supposed evidences of subsidence of the coast of New Brunswick within modern time—by J. W. Goldthwait.

Geol. Ser. 16. The Pre-Cambrian (Beltian) of southeastern British Columbia and their correlation—by S. J. Schofield.

Geol. Ser. 17. Early Cambrian stratigraphy in the North American Cordillera, with discussion of the Albertella and related faunas—by Lancaster D. Burling.

Geol. Ser. 18. A preliminary study of the variations of the plications of Parastrophia hemiplicata, Hall—by Alice E. Wilson.